

Primo MICARELLI^{1,7}, Isabella BUTTINO², Paolo BAVA¹, Giulia CAPPELLETTI^{1,7}, Noemi ANDRANI³, Martina MASSA⁴, Andrea MARSELLA^{1,5}, Enrico VERNELLI¹, Emilio SPERONE⁶, Francesca Romana REINERO¹

¹Sharks Studies Center-Scientific Institute, 58024, Massa Marittima (GR), Italy
²Italian Institute for Environmental Protection and Research (ISPRA), 57122, Livorno, Italy
³Department of Earth Science, University of Rome La Sapienza, 00185, Roma, Italy
⁴Department of Earth Science, Environment and Life, University of Genova, 16126, Genova, Italy
⁵Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe), 35020, Legnaro (PD), Italy
⁶Department of Biology, Ecology and Earth Sciences, University of Calabria, 87036, Rende (CS), Italy
⁷Department of Physical Sciences, Earth and Environment, University of Siena, 53100, Siena, Italy

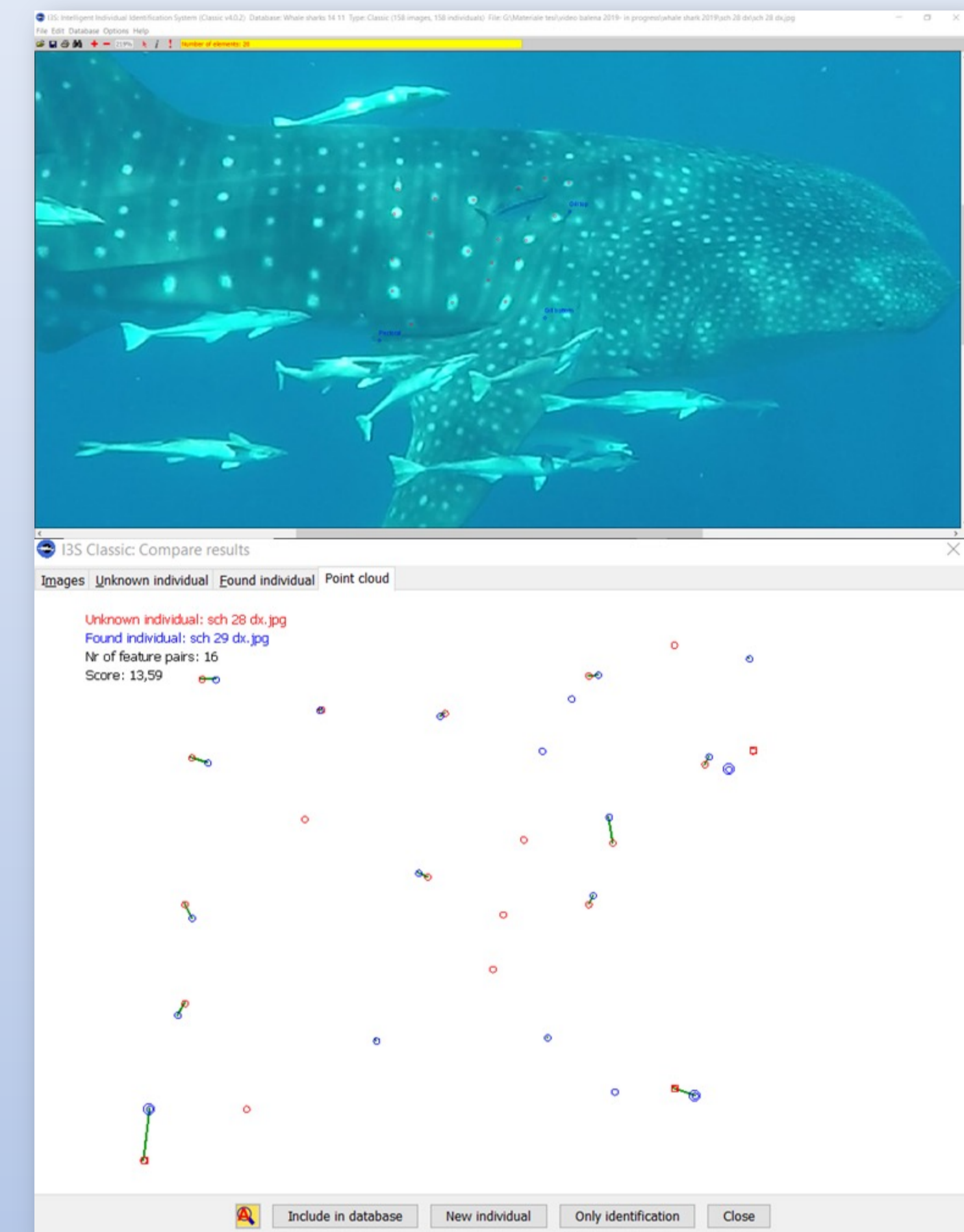
INTRODUCTION

The whale shark *Rhincodon typus*, the world's largest fish, is highly mobile, and is capable of migrating for thousands of kilometers each year. According to the IUCN Red List, areas where 500 or more individuals have been documented through either counts or model estimates include the Arabian Gulf and Gulf of Oman, Ningaloo Reef in Western Australia, Darwin Island in the Galapagos, Quintana Roo in Mexico, Inhambane province in Mozambique, Philippines, and Mahe in the Seychelles (Pierce & Norman, 2016). However, information on the global population structure and movement patterns remains limited. Recently, the whale shark population in Madagascar has been estimated at more than 400 individuals (Diamant *et al.*, 2021), while in Djibouti at about 190 individuals (Boldrocchi *et al.*, 2020). The aim of the study is to compare in the long term the two populations with a non-invasive system of identification of individual specimens, the I³S Classic program, to evaluate the possible presence of movements of individuals between these two areas.

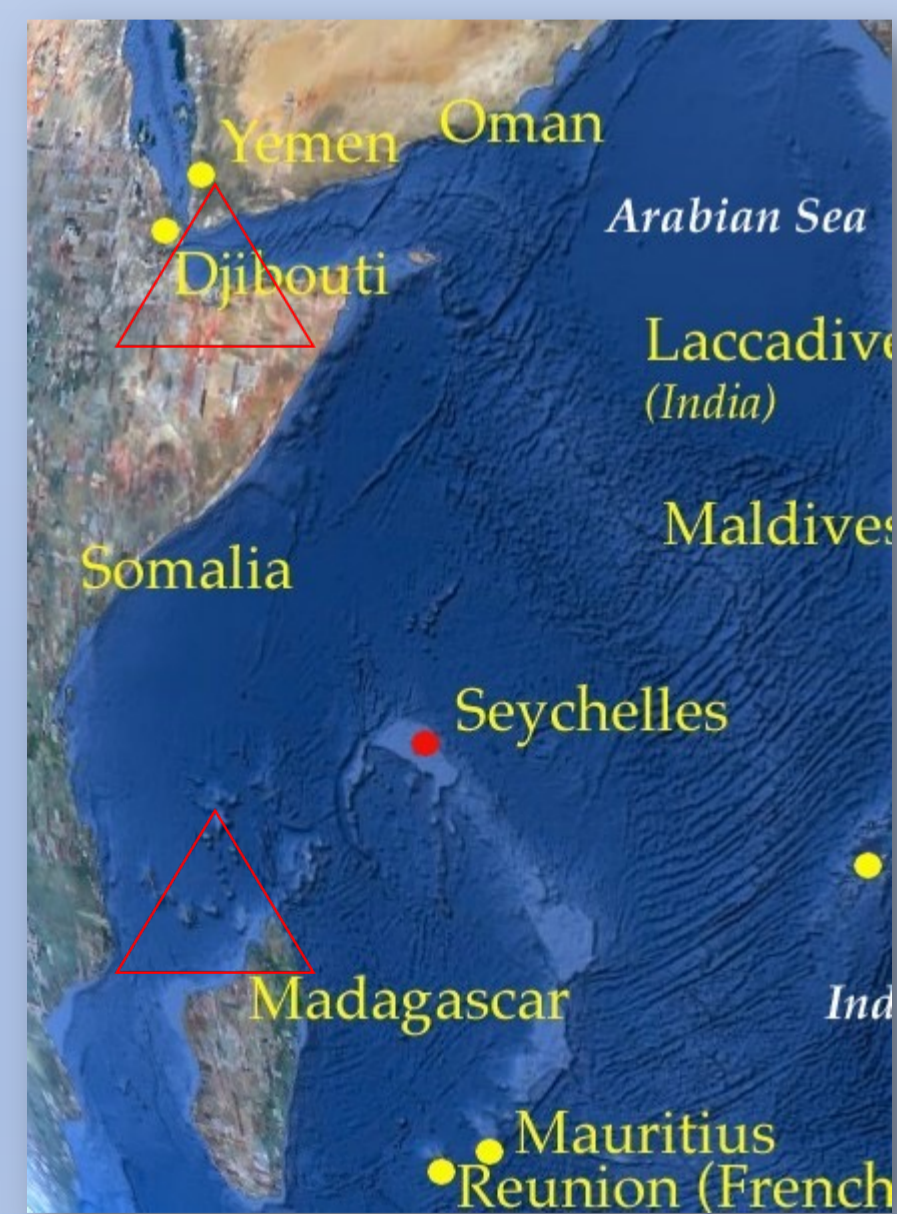


MATERIALS AND METHODS

Between 2017 and 2022, six scientific expeditions were carried out: three in Nosy Be, Madagascar (2017, 2018, and 2019), and three in Djibouti (2017, 2020, and 2022), to evaluate sharks' movements between these two areas. Nosy Be (13°39'S; 40°20'E), in the Atsinanana Province, is a volcanic island located in the Mozambique Channel, about 8 km from the Northwest coast of Madagascar. The Gulf of Tadjoura (11°40'N, 43°00'E), at the southern entrance to the Red Sea, is an inlet of the Indian Ocean caused by the fault line of the northerly end of the East African Rift Valley that transects Djibouti, Ethiopia, and Kenya (Rowat *et al.*, 2007). In Nosy Be, observations occurred between November and December when the local whale shark population is present and data collection was performed in the morning, roughly from 9:00 am to 01:00 pm, to take advantage of better sea conditions. In Djibouti, data collection occurred in January, when it is still present the local whale shark population: in 2017 and 2022 data were collected between Arta Beach (11°34'N, 42°49'E), Ras Korali (11°34'N, 42°47'E) and Escape Bay (11°34'N, 42°49'E) where, daily, 3 whale sharks' monitoring activities were performed from two tenders at the following day time ranges 07-09, 11-13, and 15-17. Observations were randomly performed 50m far the coast, covering an area of about 20 km of diameter from Ras Korali; in 2020 data were collected also in the Gulf of Goubet. Informations including shark ID, day of sighting, presence of scars, sex, and estimated total length were collected for each encountered animal and the unique spot patterns were acquired. The same authors analyzed the data provided by all the expeditions and compared the unique spot patterns through the I³S Classic photo-identification software.



I³S Photo-identification program



Sampling area



Djibouti (left) and Nosy Be, Madagascar (right)



RESULTS AND CONCLUSIONS

Totally, 77 specimens (19% of the total estimated) were identified in Madagascar and 41 (21% of the total estimated) in Djibouti and no matches occurred. The length varied between 2.5m and 6.5m and all the juveniles and the majority of the specimens were males. Further data collection activities are planned to increase the number of individuals identified and to eventually confirm the segregation of the whale shark population between these two areas in the Indian Ocean.



23/11/2018 10:17

REFERENCES

- Boldrocchi, G., Omar, M., Azzola, A. *et al.* (2020) The ecology of the whale shark in Djibouti. *Aquat Ecol*, 54, 535–551. <https://doi.org/10.1007/s10452-020-09758-w>
- Diamant, S., Pierce, S.J., Rohner, C.A., Graham, R.T., Guillemain d'Echon, A., Guillemain d'Echon, T. *et al.* (2021) Population structure, residency, and abundance of whale sharks in the coastal waters off Nosy Be, north-western Madagascar. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 31(12), 3492–3506. <https://doi.org/10.1002/aqc.3743>
- Pierce, S.J. & Norman, B. (2016) *Rhincodon typus*. The IUCN Red List of Threatened Species 2016: e.T19488A2365291. <https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T19488A2365291.en>.
- Rowat, D., Meekan, M.G., Engelhardt, U., Pardigon, B., Vely, M. (2007) Aggregations of juvenile whale sharks (*Rhincodon typus*) in the Gulf of Tadjoura, Djibouti. *Environ Biol Fish*, 80(4), 465–472